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SUMMARY PAGE

THE PROBLEM

Controversy still exists as to whether the forehead sweat glands respond to both arousal and thermal stimuli. This study was carried out to determine the precise nature of the forehead sweat response during the elicitation of motion sickness by vestibular stimulation.

FINDINGS

None of the fifteen subjects showed any arousal type sweat responses at the time of onset of the vestibular stimulation. Two of the subjects showed no evidence of any forehead sweating despite an advanced degree of nausea. For the remaining thirteen subjects, a forehead sweat response was obtained after a latent period that ranged anywhere from 5 seconds to 4 minutes. Once initiated, the response tended to increase in magnitude as long as the stimulus was continued. This pattern of response is characteristic of most symptomatology seen in motion sickness.

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INTRODUCTION

It is well known that sweating on the palms of the hands and the soles of the feet occurs in response to arousal stimuli, whereas sweating on other skin areas generally occurs in response to thermal stimuli. McClure et al. (7) showed independent palmar and dorsal-hand sweat responses during vestibular stimulation. In that study palmar sweating was found to be greatest during the period immediately following the onset of vestibular stimulation. In contrast to this, sweating on the dorsal hand was observed only after a relatively long latent period following the onset of vestibular stimulation, and once initiated, the magnitude of the response increased gradually with continuation of the stimulus.

The nature of forehead sweating has been a controversial topic for many years. McGregor (10) showed both thermal and emotional sweating on the forehead, using a starch-iodine patch technique for sweat detection. In that study carried out on a group of students, the emotional stimulus consisted of telling the subject part way through an oral examination that he had passed. A study of the graphs presented by McGregor reveals that the palmar sweat response in those subjects was of sudden onset and had a latency of less than 20 seconds, which is typical of an arousal type response. On the other hand, the forehead sweat response increased gradually over a period of 1 minute or more, which is less typical of an arousal response. Kuno (6) in his experiments was unable to show forehead sweating in response to the stress of mental-arithmetic testing. He doubts that emotional sweating as reported by McGregor is found regularly in normal subjects.

The forehead sweat response during motion sickness has not been adequately defined despite the fact that this is a common area to examine for sweat responses during the development of motion sickness (2-4).

Hemingway (5) used a skin-resistance technique to show cold sweating on the forehead during exposure to periodic motion. He described the sweat response during motion sickness as similar to that which occurs during mental stress. He also dissociated motion-sickness sweating from thermal sweating because motion-sickness sweating can occur in a relatively cold environment. However, in a recent study (9) it has been shown that motion sickness sweating is, in fact, greatly influenced by the environmental temperature.

Behr et al. (1) monitored skin-resistance changes on the forehead during vestibular caloric tests. Although the majority of subjects failed to show a skin-resistance change at the onset of the thermal stimulation but did show a pronounced fall in skin resistance (indicative of sweating) 2 to 3 minutes later, the graphical example in that report which does show an initial fall in skin resistance suggests that arousal sweating can occur on the forehead.

PROCEDURE

SUBJECTS

Fifteen young men ranging in age from 17 to 31 years served as subjects. All were vacationing college students who volunteered for the experiment. The subjects received generous remuneration for their services. All subjects were in good health; however, no specific medical or vestibular tests were carried out.

APPARATUS

Motion sickness was elicited by subject-induced side-to-side head movements while the subject was on a motor-driven chair rotating at constant velocity about a vertical axis.

Sweating was detected by two independent techniques. The skin resistance sensor (SRS) consists of two Beckman miniature skin electrodes and a Sanborn 350-12 GSR bridge as a constant current source. Current is passed in and out across the skin surface at the electrode sites. Changes in the voltage difference between the two electrodes reflect the skin-resistance changes that occur during sweating. The second technique uses an electrochemical sensor (ECS) that is described in detail elsewhere (8). This sensor contains a $\text{LiCl} \cdot \text{H}_2\text{O}$ - AlCl_3 sensing element and responds to the moisture content of air that is passed over the skin surface.

All runs were carried out in an environmental chamber in which the room temperature could be selected.

METHOD

Each subject experienced one run with both the SRS and the ECS mounted on the forehead as illustrated in Figure 1. Prior to the run, subjects were required to refrain from physical exercise and preferably spent the time in an air-conditioned environment. Subjects were acclimatized at run temperature in the environmental chamber for a minimum of 20 minutes. All runs were carried out with the room temperature maintained between 72°F and 74°F (except in two cases where the room temperature was maintained between 75°F and 76°F).

Rotation of the subject was always in the counterclockwise direction. The particular chair velocity selected for each individual was based on an estimation of his sensitivity to motion sickness as determined by his previous experience in a rotating environment and his personal history of motion sickness in various transport vehicles.

After acceleration (about $1^\circ/\text{sec}^2$) to required velocity and a stabilization period of at least 1 minute, the subject was given verbal instructions to get ready for head movements. The subject commenced head movements on his own at least 10 to 15

seconds later. Head movements were continued until both sweat sensors indicated significant sweat activity or until the subject reached a nausea endpoint* that he estimated to be close to vomiting.



Figure 1

Placement of sweat sensors on the forehead.
Electrochemical sensor (A); skin resistance
sensor (B).

* The nausea endpoint was an NIV level measured on a five-point scale. NI denotes the first sensation in the stomach while NV denotes the feeling one has just prior to vomiting. NII, NIII, and NIV are levels that the subject estimates to be equally spaced between NI and NV.

RESULTS

Figure 2 illustrates forehead sweat responses from four of the fifteen subjects. None of the subjects showed any sweat activity at the time of onset of the vestibular stimulation. Two of the subjects showed no evidence of any forehead sweating despite

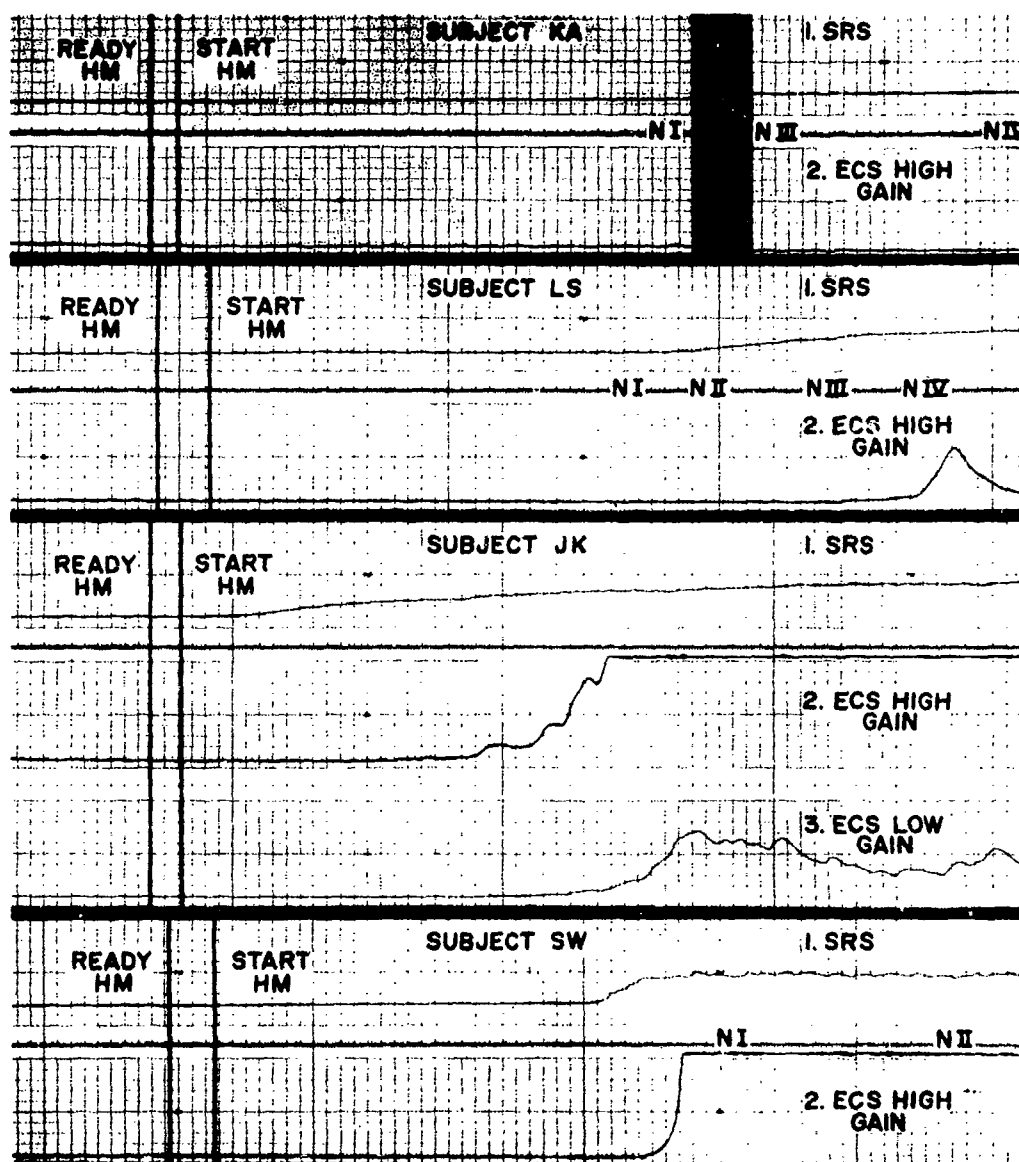


Figure 2

Forehead sweat response from four subjects. Note absence of activity at onset of vestibular stimulation for all subjects and during complete run for subject KA (intervening trace between NI and NIII unchanged). HM: head movements. SRS: skin resistance sensor. ECS: electrochemical sensor. NI to NIV: nausea levels (see text for explanation). Paper speed 1 mm/sec.

an advanced degree of nausea. For the remaining thirteen subjects, a forehead sweat response was obtained after a latency that ranged anywhere from 5 seconds to 4 minutes. Once initiated, the sweat response tended to increase in magnitude as long as the stimulus was continued.

DISCUSSION

The fact that sweating was not seen at the time of onset of the vestibular stimulation suggests that the forehead is not an active arousal sweat area. This is in contrast to the palm of the hand (a known arousal sweat area) where the onset of vestibular stimulation can induce an immediate sweat response (7).

The pattern of forehead sweat (i.e., relatively long latency to sweat onset and thence a gradually rising level of response) is similar to that which occurs on the dorsal hand (7). This pattern is characteristic of most motion-sickness symptomatology and resembles the forehead sweating obtained by Hemingway (5) and Crampton (2) during motion sickness. The similarity of the forehead and dorsal-hand responses suggests that the forehead, like the dorsal hand, is predominantly a thermal sweat area, and its sweat response during motion sickness would be influenced by changes in environmental temperature (9). It is probable that for the two subjects who showed no sweat activity, a sweat response could have been obtained by raising the environmental temperature a few degrees.

A direct comparison of forehead and dorsal-hand sweating during the same experimental run was not made. However, for certain subjects who had been used in earlier experiments, the forehead response could be compared with the dorsal-hand response from a previous run. These comparisons were made for runs that were carried out at the same angular velocity, with the same head movement pattern, and at the same environmental temperature. Figure 3 illustrates forehead and dorsal-hand sweat responses from two subjects. Forehead sweat responses tended to be of smaller magnitude than dorsal-hand responses. Such a result is unexpected since Weiner and Hellmann (11) reported that the eccrine sweat glands are nearly twice as numerous per unit area on the forehead as they are on the limbs. The findings suggest that the forehead may not be the best area to monitor sweat-gland activity during motion sickness.

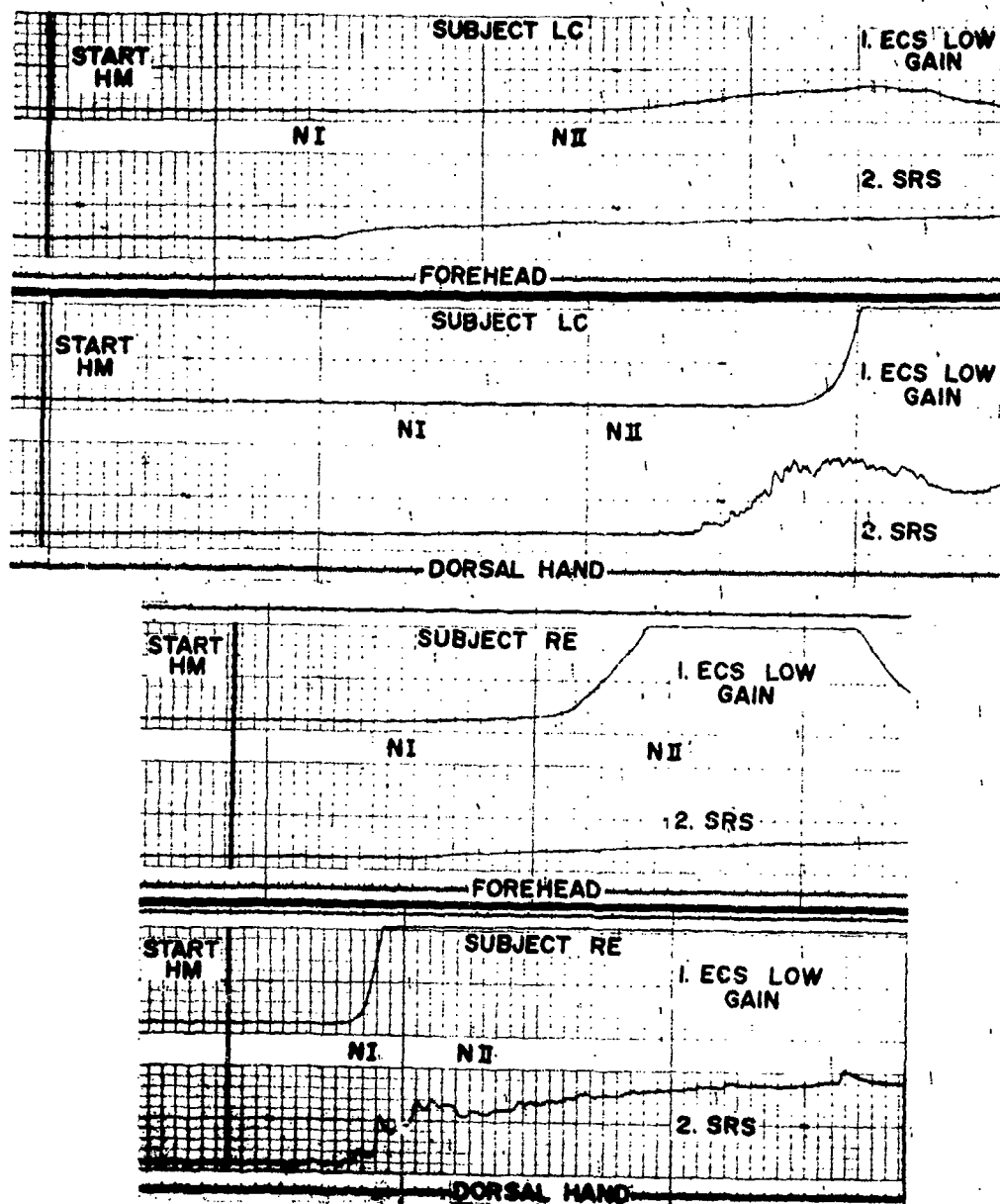


Figure 3

Comparison of forehead and dorsal-hand sweat responses for two subjects during the development of motion sickness. HM: head movements. SRS: skin resistance sensor. ECS: electrochemical sensor. NI and NII: nausea levels (see text for explanation). Paper speed 1 mm/sec.

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13. ABSTRACT Forehead sweating was monitored on fifteen subjects during the elicitation of motion sickness by vestibular stimulation. An electrochemical sweat sensor and a skin-resistance technique were used simultaneously to detect the sweat responses. None of the subjects showed any arousal type sweat responses at the time of onset of the vestibular stimulation. Two of the subjects showed no evidence of any forehead sweating despite an advanced degree of nausea. For the remaining thirteen subjects, a forehead sweat response was obtained after a latent period that ranged anywhere from 5 seconds to 4 minutes. Once initiated, the response tended to increase in magnitude as long as the stimulus was continued. This pattern of response is characteristic of most motion-sickness symptomatology. For certain subjects the forehead sweat response was compared with their dorsal-hand response obtained from a previous run carried out under the same standard conditions. These comparisons suggest that the forehead is a less active sweat area than the dorsal hand during motion sickness. <div style="text-align: center;">Details of illustrations in this document may be better studied on microfiche</div>		

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